CDHD Servo Drive

Technical Training Manual

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Firmware Version: 1.3.x
Software Version: 1.3.x.x

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Revision History

Document Revision	Date	Remarks
1.0	June 2012	Initial release
2.0	Sept.2012	Corrections; Added Chapters 11, 12, 13

Firmware Revision	Software (GUI) Revision
1.3.x	1.3.x.x

Important Notice

Disclaimer

The information in this manual was accurate and reliable at the time of its release. Servotronix Motion Control Ltd. reserves the right to change the specifications of the product described in this manual without notice at any time.

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Technical Support

If you need assistance with the installation and configuration of the CDHD drive, contact Servotronix technical support: tech.support@servotronix.com

Contents

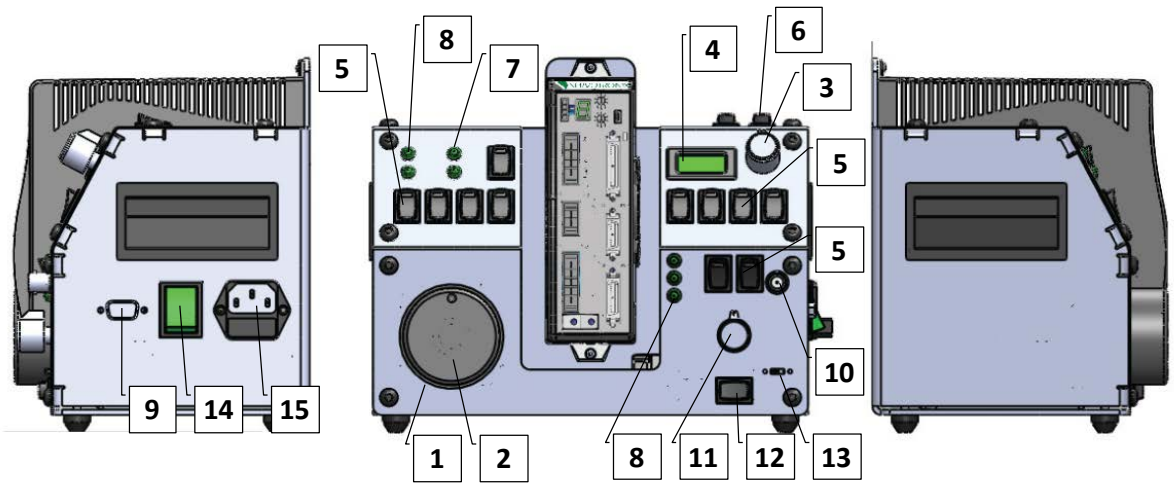
1 Introduction

1.1 About the Demo Kit

The CDHD Demo Kit showcases the performance and functionality of the CDHD servo drive. The portable unit can be easily carried and used at demonstration and training sites.

The CDHD Demo Kit consists of a servo drive, a motor and a number of elements that emulate external inputs and outputs interfaces.

This training manual will guide you through a series of exercises in which you will use the Demo Kit, along with ServoStudio software, and learn how to properly configure, program and operate the CDHD drive.



Item	Component Description	Demonstration of CDHD Function
1	**Motor** AC servo motor, 400 W	Motor operation, velocity position profile, tuning, etc.
2	**Inertia Load** Aluminum disk connected to the motor shaft	Acceleration, deceleration
3	**Analog Input (ANIN 1)** Dial, to control ±10V supply to the CDHD	Analog current loop, Analog velocity loop
4	**LCD Display** Shows the input voltage provided by ANIN 1	

Item	Component Description	Demonstration of CDHD Function
5	**Input Switches** 11 switches with green LED, labeled IN1, IN2 ... IN11.	Configurable input functions, such as enable, clear faults, limits, execute script file, trigger motion, homing, etc.
6	**STO Switches** 2 switches with green LED	Safe torque off. Two switches (24V supply and 24V return). Both must always be on.
7	**Fault Relay** 1 green LED	Configurable fault relay functions, such as drive status, changing relay condition, etc.
8	**Outputs** 6 green LEDs, labeled OUT1, OUT2, ... OUT6	Configurable output functions, such as drive status, brake, etc.
9	**Encoder Simulation Output** D9 male connector	Encoder output.
10	**Analog Output Connector** BNC connector, to supply 0-10V analog output to scope or voltmeter	Measure and record configurable output functions, such as velocity, position error.
11	**External Pulse Generator** Dial with an electronic resolution of 120 pulses per revolution (PPR). Generates A and B signals, with 90° shift.	Either pulse or secondary feedback, master and slave, electronic gearing.
12	**Pulse Generator Selector Switch** Toggles the pulse generator connection between Machine interface (I/F) and Controller interface (I/F)	Machine interface: secondary encoder feedback. Controller interface: pulse and direction feedback.
13	**P&D Direction Switch** Defines pulse direction, when pulse generator switch is set to Controller I/F. 3 settings: counterclockwise / P&D / clockwise	
14	**Power Switches** 2 switches: one for Demo Kit internal power supply; one for CDHD AC input. (older Demo Kit models have only one power switch)	
15	**Power Connector** Plug for connecting AC power to unit.	

1.2 Training Resources

Only essential background information is included in this training manual. For more information and explanations about the CDHD hardware and software systems, use the following resources:

- **CDHD User Manual PDF**. Hardware installation, configuration and operation.
- **CDHD VarCom Reference Manual PDF**. Parameters and commands used to program the CDHD.
- **ServoStudio Online Help**.

  The **Help** button in the ServoStudio toolbar or **F1** opens the CDHD online help.

  Alternately, right-click on any screen or screen element, and select the **Help** option. The Help tool opens to the relevant section and explanation.

2 Connecting to the Drive

2.1 Objectives

In this session you will connect the CDHD to the PC, and establish communication between the two.

2.2 Resources

Refer to the following sections in the CDHD User Manual:

- Connect to PC (Section 3.8)
- ServoStudio Software Installation (Section 3.10)
- Power Up (Section 3.11)
- Connecting to the Drive (Section 5.4)

Note the location of the power connector and power switches on the right side of the Demo Kit:

2.3 Procedure

1. Before turning on power, make sure all switches on the Demo Kit are set as follows:
   - All input switches except **IN 1** are **off**.
   - Digital Input 1 switch **IN 1** (Remote Enable) is **on**.
   - STO Safety Torque OFF switches are **on**.
   - **ANIN 1** dial is at the top center position.
   - The Pulse Generator Selector Switch can be in either position.
2. Using the power cable supplied with the unit, connect the Demo Kit to the power supply.
3. Turn on the power switch.

Note:	On power up, the Fault relay LED may light up, depending on the settings in the ServoStudio Digital I/O screen.

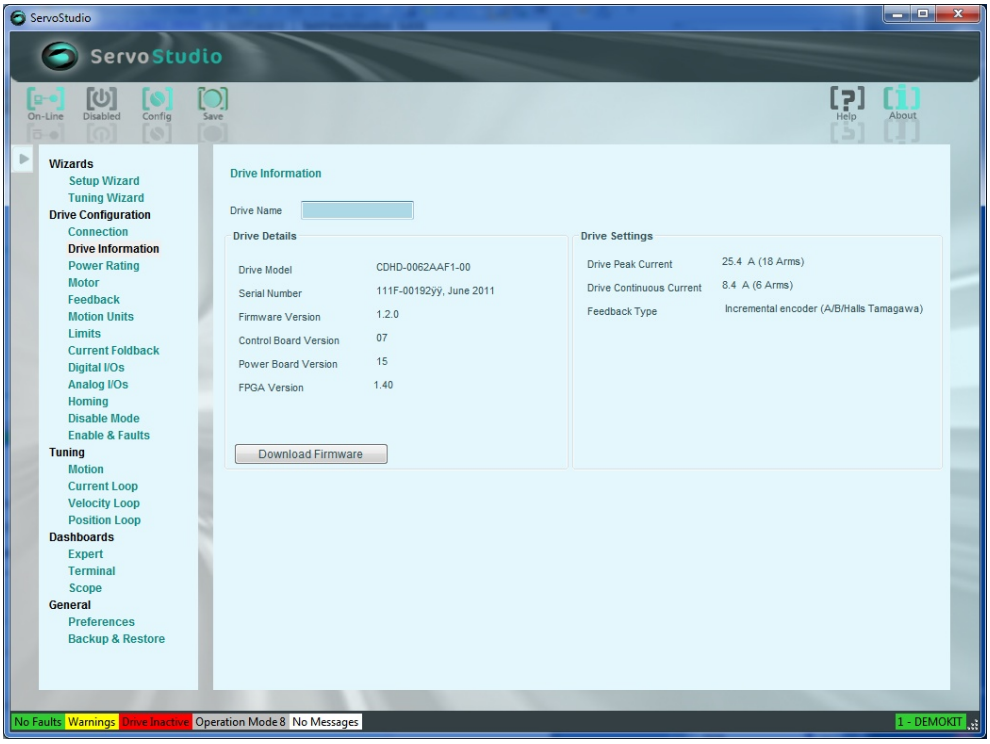
4. Connect a USB cable to interface **C1** on the CDHD and to your PC.

5. Activate the ServoStudio software from the Windows Start menu or the shortcut on your desktop.

   If you do not have ServoStudio on your PC, download and install the software from this link:

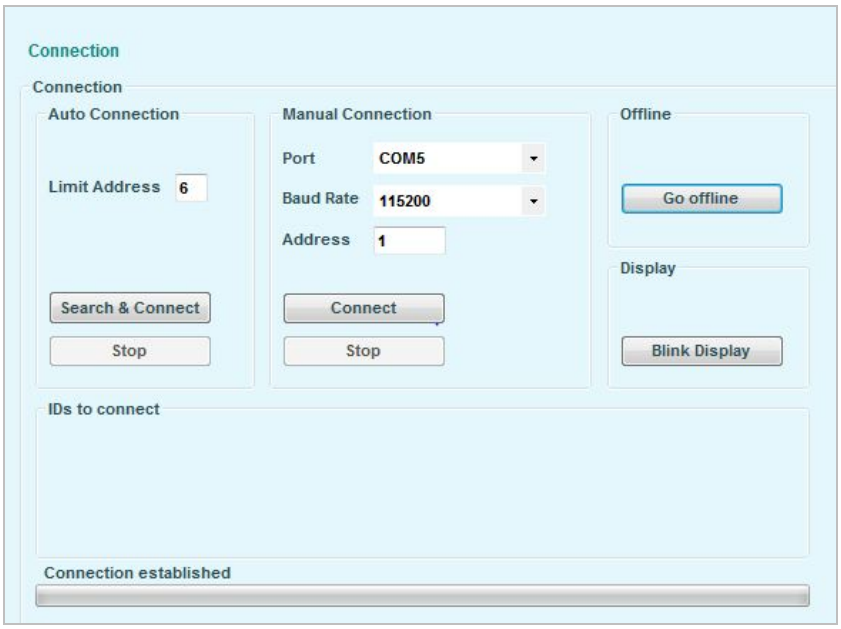
   http://www.servotronix.com/CDHD.html > Software | **ServoStudio GUI**

6. ServoStudio opens with this screen displayed:



7. Establish the connection between the CDHD and the PC.

   - From the ServoStudio navigation sidebar, click **Connection**.
   - The **Connection** screen is now displayed.



8. You can use either of the following options to connect to the drive:
   - **Auto Connection**. Click **Search & Connect**.
   - **Manual Connection**. Set the COM port, the baud (data transfer) rate, and the address, and click **Connect**.

   Practice both methods.

9. Click **Go Offline** and **Blink Display** to see their effect.

Now, that you can communicate with the CDHD, you can begin working with the drive.

3 Motor Setup – Setup Wizard

3.1 Objectives

In this session you will use the ServoStudio Setup Wizard to define and set up the motor for operation.

3.2 Resources

ServoStudio has a database containing predefined sets of parameters for motors. You can use the wizard when the motor is listed in the ServoStudio database.

When working in ServoStudio, hover over a parameter name to view its VarCom equivalent and/or descriptions. Right-click on a parameter to activate Help.

For more information about VarCom commands and variables, refer to the VarCom Reference Manual. Alternately, use ServoStudio Help.

Refer to the following sections in the CDHD User Manual:

- Setup Wizard (Section 5.3)
- Connecting to the Drive (Section 5.4)
- Drive Information (Section 5.5)
- Power Rating (Section 5.6)
- Motor (Section 5.7)
- Motor Feedback (Section 5.8)
- Motor Phasing (Section 6.11)

Note the location of the motor label on the top left side of the Demo Kit:

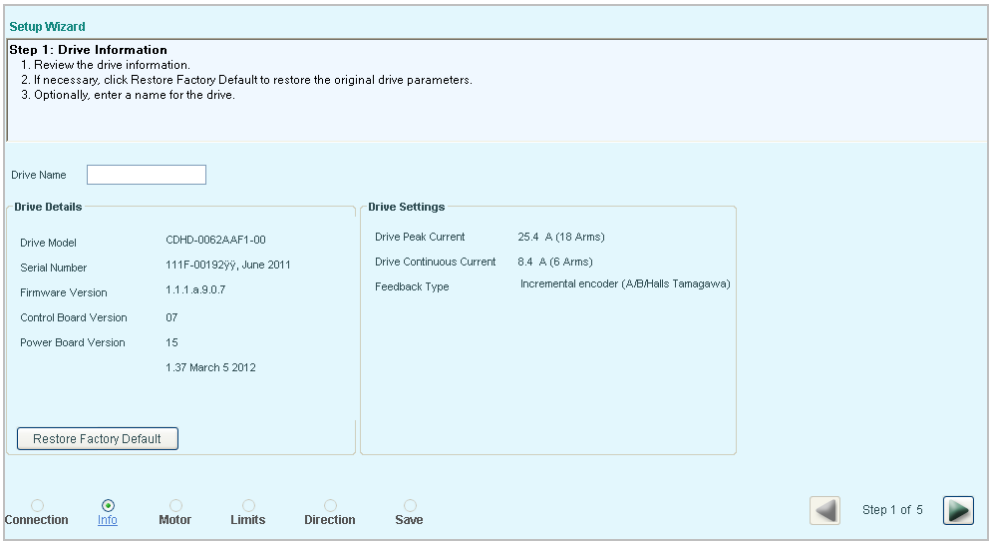
3.3 Procedure

Setup Wizard

1. Locate the Demo Kit's motor label.

2. From the ServoStudio navigation sidebar, select **Setup Wizard**.

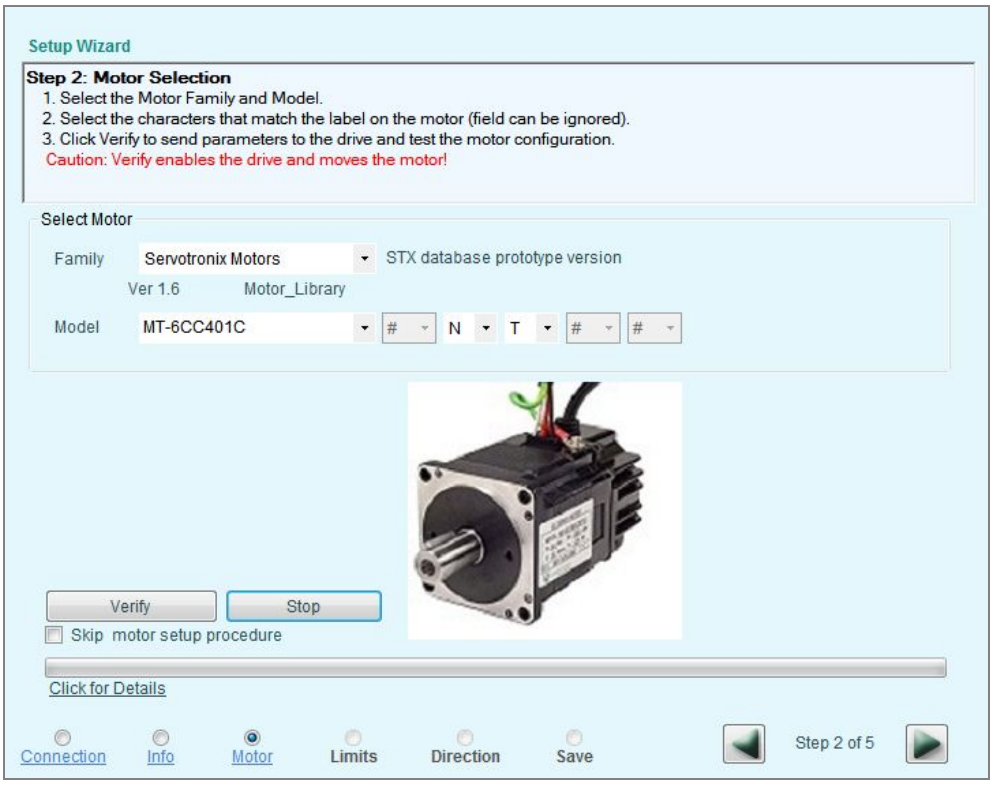
If the drive is already connected, the Wizard skips Step 0 and begins at Step 1 – Drive Information:



- Click the **Restore Factory Default** button to reset the drive parameters to their original state.
  At the prompt to save parameters, press **No**.
- Enter a Drive Name such as **DEMOKIT**. This is optional.
- Click the **Next** arrow to continue.

3. In Step 2 of the Setup Wizard, select the motor used in your application. For the motor in the CDHD Demo Kit, select:

- Motor Family: **Servotronix Motors**
- Model: **MT-6CC401C**-3**NT**3



4. Click the **Verify** button to send the parameters to the drive and test the motor configuration.
   At the warning, press **OK**.
5. Wait for the Motor Setup Succeeded message. Then click the **Next** arrow to continue.
6. In Step 3 of the Setup Wizard, set the application's **Velocity and Current** limits.

   Setup Wizard suggests values for Low, Medium or High current and velocity limits, which are rounded to 25%, 50% and 75%, respectively, of the maximum range.

   Click the **Approve** button to confirm the default **Medium** values.
7. Click the **Next** arrow to continue.
8. In Step 4 of the Setup Wizard, define the rotation direction for a positive command.
   - To verify motor motion direction, click either **Negative** or **Positive** several times while observing the movement of the motor shaft disk
   - To reverse the direction to match your system, select **Inverse Direction**.
   - When satisfied with the results, click **Approve Direction**.
9. Click the **Next** arrow to continue.
10. In the last step of the Setup Wizard, **save** the parameters.
    - Save the parameters to the drive, so that you will not need to repeat the setup process after resetting the drive.
    - Save the parameters to a file (SSV file) on your computer, for backup and/or for use on other drives.

Once the Setup Wizard is completed, the **Current** control loop is configured at a basic level.

11. Click the **Save to Drive** option.

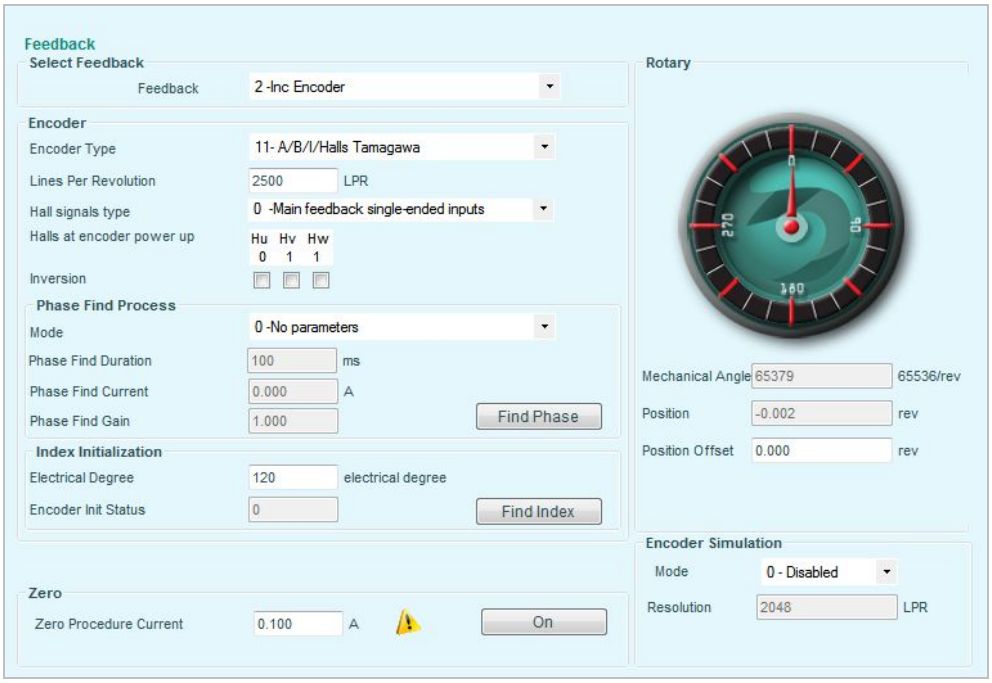
12. Click the **Save to File** option. Save file as **DEMOKIT1.SSV**

Do **not** click the **Next** arrow.

Feedback

1. From the ServoStudio navigation sidebar, open the **Feedback** screen and make sure that feedback is configured properly.

Review all feedback definitions. You should see the following:



2. Take hold of the inertia load disk, and turn it manually one complete revolution. Watch the graphic dial in the software, and make sure it also rotates exactly one revolution in the same direction.

3. Turn the disk one complete revolution in the opposite direction, and make sure the software accurately reflects the movement.

Notes: Hall sensors are read at power up. The values on your screen may be different than the ones shown here.

Each rotation is equivalent to exactly 10000 encoder counts, which is also the equivalent of 2500 lines per revolution × 4.

4 Automatic Tuning – Tuning Wizard

4.1 Objective

In this session you will use the ServoStudio Tuning Wizard to tune the CDHD position loop in order to optimize and evaluate the drive's performance.

4.2 Resources

CDHD has two position control loop options – linear and HD (non-linear)control. The HD control algorithm is designed to minimize position error during motion and to minimize settling time at the end of motion. The Tuning Wizard is used to set the initial HD controller parameters.

Refer to the following sections in the CDHD User Manual:

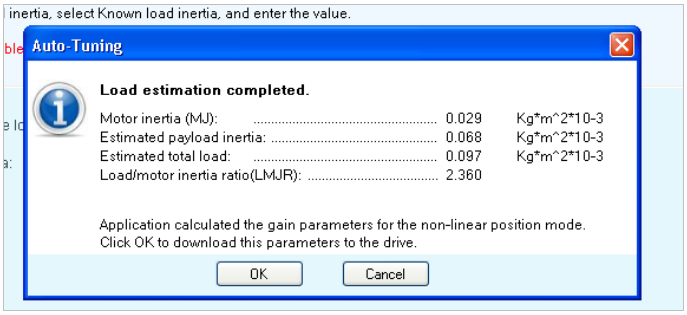
- Tuning Wizard (Section 5.16)

4.3 Procedure

1. From the ServoStudio navigation sidebar, select **Tuning Wizard**.
2. In Step 1 of the Tuning Wizard, you are prompted to enter the inertia of the load or to let ServoStudio estimate it automatically.

   Select **Move and estimate load inertia** and click **Start** to let ServoStudio do it. This process may take few seconds.

   When done, the results of the estimation are displayed:



3. Click **OK**.

   ServoStudio sets the preliminary control parameters for the NLP controller.

   The next steps are fine tuning for optimizing performance.
4. Click the **Next** arrow to continue.
5. In Step 2 of the Tuning Wizard, you are prompted for the Move command parameters to be used in the auto tuning process.

   The displayed **Move Command** values are recommended values; they have been determined according to the motor you defined in the setup.

In an actual application, it may be necessary to modify the **Distance** and **Speed** settings. For now, do not change these values.

6. Click **Start**.

The motor moves back and forth continuously, while ServoStudio tests values at intervals throughout the range for each of the control loop parameters. Once it achieves the best result, it displays the optimal value in the parameter table.

Watch the Parameter table.

7. In Step 3 of the Tuning Wizard, you test the quality of motion.

Click **Move and Plot** to send a Position command to the drive and plot the step response.

8. Makes sure **Alternating** is selected and repeat **Move and Plot**.

9. Note the Settling Time and Position Error Window values.

Try selecting and/or changing the various options in this screen.

You can improve the motion by changing the value of the NL adaptive gain scale factor (KNLUSER). This parameter affects all controller gains for the non-linear position loop.

A higher gain value results in stiffer control, and a lower value results in softer control.

10. Click the **Next** arrow to continue.

11. In the last step of the Tuning Wizard, save the parameters to the drive and/or to a file.

12. Click the **Save to Drive** option.

13. Click the **Save to File** option. Save file again as **DEMOKIT1.SSV**

5 Basic Operation – Velocity Control Loop

5.1 Objective

In this session you will:

- Issue **velocity** commands to the drive.
- Record the motor speed while a velocity command is executed.

5.2 Resources

Refer to the following sections in the CDHD User Manual:

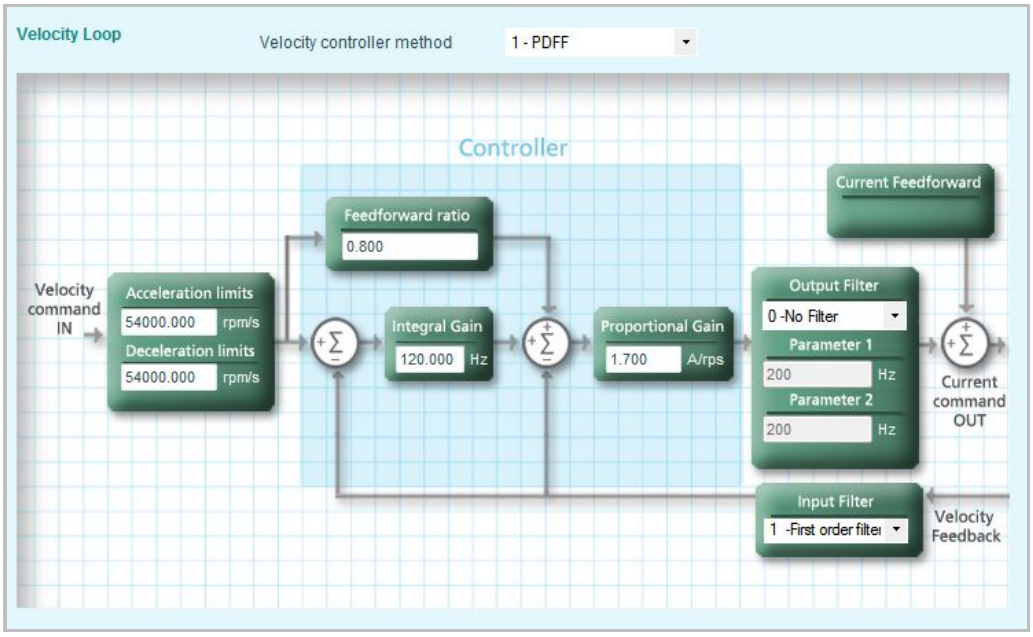
- Serial Velocity Mode (Section 6.5)
- Data Recording, Scope Screen (Section 6.14)

5.3 Procedure

Velocity Control Loop

1. ServoStudio does not include an automatic velocity loop tuning, and this training manual does not cover manual tuning of the velocity loop.

Therefore, to ensure that the velocity commands you are about to issue will rotate the motor, open the **Velocity Loop** screen:



2. Do the following

- Make sure drive is online and disabled:

- Set Velocity controller method to **1-PDFF.**
- Enter parameter values as shown in the screen above.
- Save the settings by clicking the **Save** button on the ServoStudio toolbar.

Notes:	After entering a value in a parameter field, press **Enter** and verify that the field turns white. Whenever you change the value of any parameter, click **Save**.

Velocity Command

1. Open the **Motion** screen.

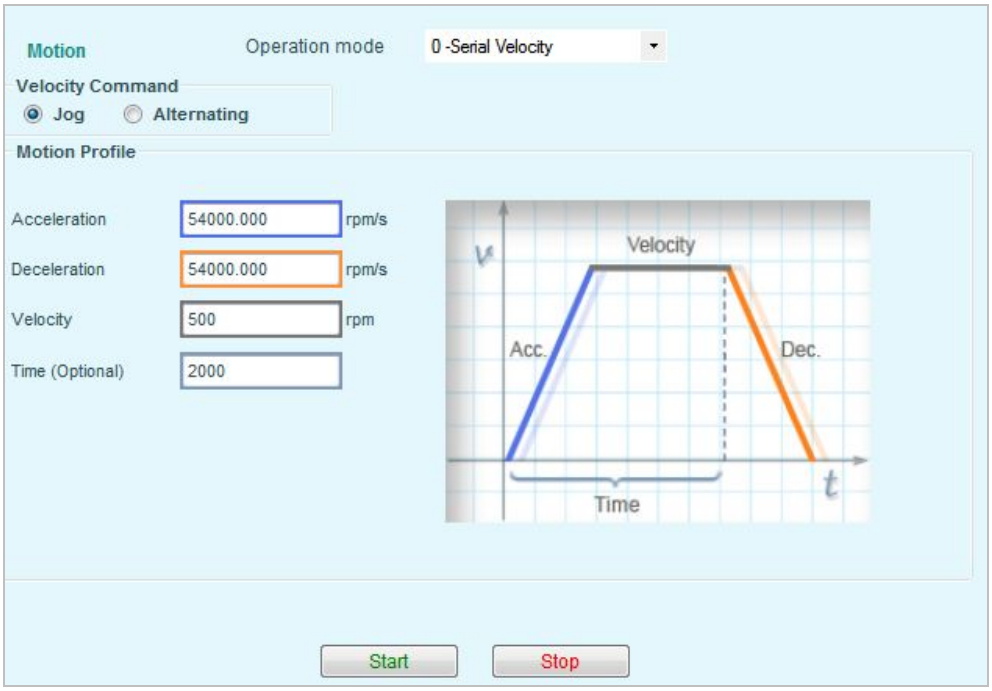
You will see the values you entered in the Velocity Loop screen displayed in the relevant fields in this screen.

- Make sure drive is online and disabled.
- Set the Operation mode to **0-Serial Velocity**.

Notes:	The drive must be disabled whenever the operation mode (OPMODE) is changed. If you see the error message **Drive Respond: ERR23 Drive Active**, disable the drive.

2. Define a velocity **Jog** command to move the motor at 500 rpm for 2 seconds.

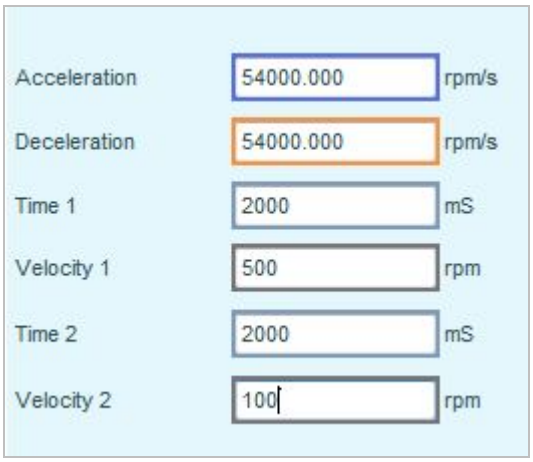
- Enter parameter values as shown in the screen below.



- Enable the drive.
- Click the **Start** button to start the motor.
- Observe the movement of the inertia load disk.

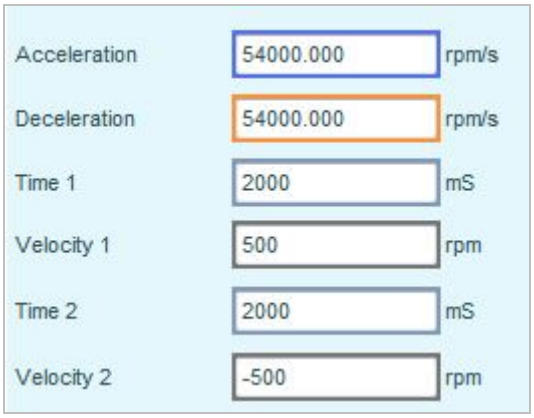
3. Change the velocity command to **Alternating**.

- Enter parameter values as shown in the screen below.



- Click the **Start** button to start the motor.
- Observe the movement of the inertia load disk, and press **Stop**.

4. Enter parameter values as shown in the screen below.



- Click the **Start** button to start the motor.
- Observe the movement of the inertia load disk, and press **Stop**.

Recording

1. Open the **Scope** screen.

2. Select the **Motion** tab.

3. In the Motion pane, enter values as shown in the screen below:

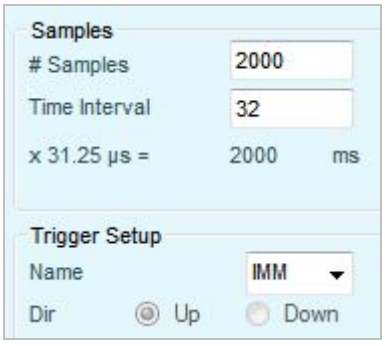
4. Click **Start** and verify the motion.

5. To record the position command, you first need to define the recording properties

   Using the **Recorder Setup** pane in the Scope screen, setup a recording of the velocity command, motor speed and current command for 2 seconds".

   - Define the number of samples. Set to the maximum **2000**.
   - Define the time interval between the samples. Set to **32**.

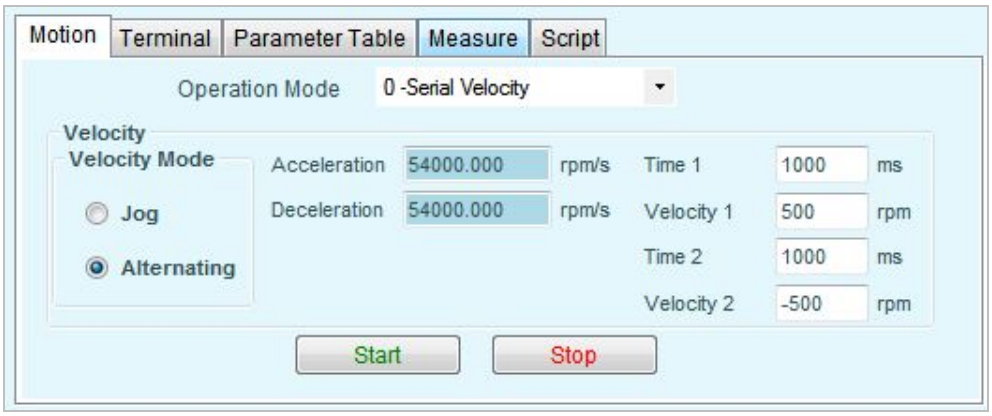
     The interval value is specified in multiples of the drive's basic sampling rate, which is 31.25 µs.
   - Define the record trigger. Set to **IMM** for immediate activation
   - Select the record variables. Up to 3 variables can be recorded simultaneously. Select the variables **VCMD** (velocity command), **V** (measured velocity), and **ICMD** (current command).



6. To start recording, make sure drive is enabled, then click the **Move Record and Plot** button in the Scope toolbar.

The plot soon appears:

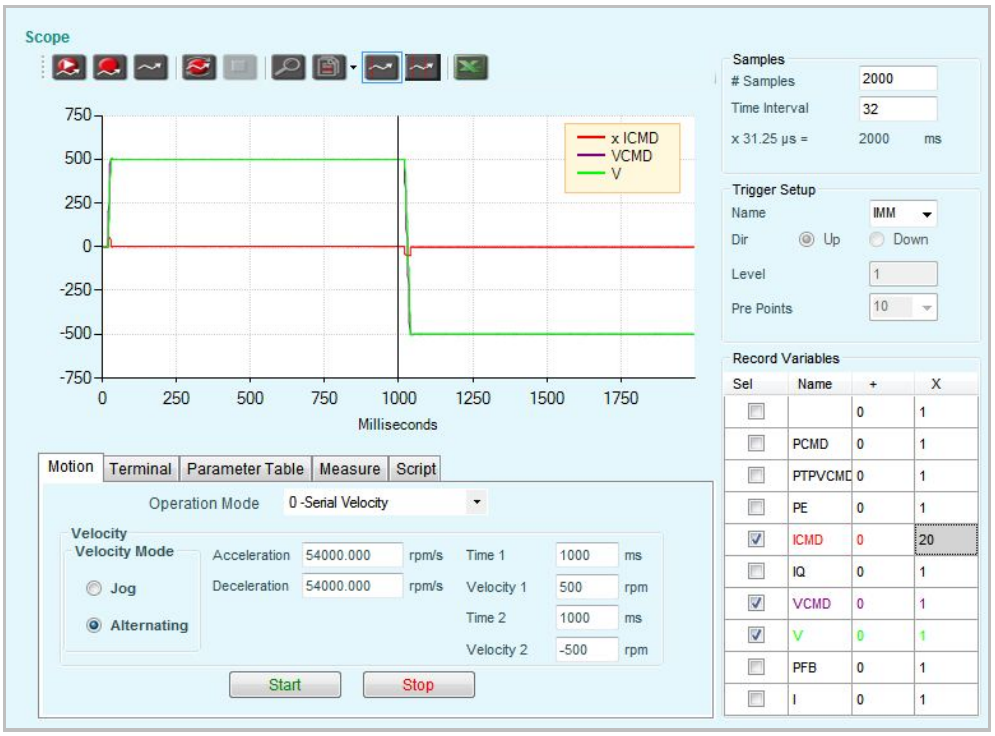
7. Switch to an **Alternating** movement, and enter values as shown in the screen below.



- Click **Start** and verify the motion.
- Click the **Move Record and Plot** to repeat the movement and record.

8. Sometimes, you may want to change the scaling of a recorded variable because its trace may be too small to view properly (because the graph is scaled to the largest value of another variable).

For example, in the screen below, the variable **ICMD** is scaled by **20** to make the position error more clearly visible in the graph.



Notes: Be sure to press **Enter** upon entering a scaling factor.

Whenever an enlarged trace is in effect, the character **x** is displayed next to the variable name in the legend.

6 Basic Operation – Position Control Loop

6.1 Objective

In this session you will:

- Issue **position** commands to the drive.
- Rotate the motor a specific distance and speed.
- Continuously record motion.

6.2 Resources

Refer to the following sections in the CDHD User Manual:

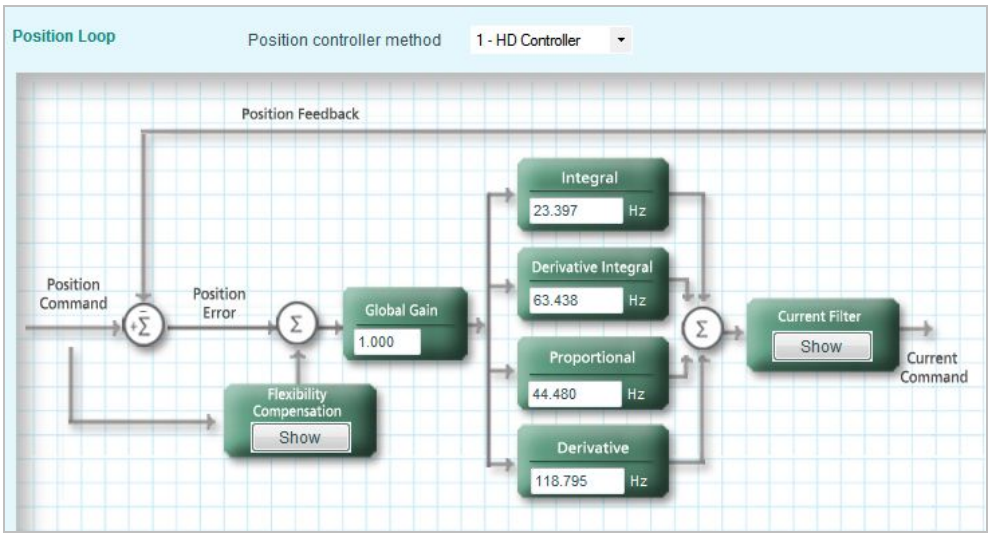
- Serial Position Mode (Section 6.7)
- Data Recording, Scope Screen (Section 6.14)
- Motion Units (Section 5.9)

6.3 Procedure

Position Control Loop

1. Open the **Position Loop** screen, and do the following:
   - Make sure drive is online and disabled.
   - Set Position controller method to **1-HD Controller.**
   - Make sure you see parameter values in the fields on the screen. The numbers on your screen may differ slightly from the ones shown below, depending on the results of the autotuning you performed.
2. Save the settings by clicking the **Save** button on the ServoStudio toolbar.

Note:	Whenever you modify parameter values, operation mode, or controller method, click **Save**.



Incremental Position Command

1. Open the **Motion** screen.

- Make sure drive is online and disabled.
- Set the Operation mode to **8-Position**.

2. Define an incremental motion command that will move the motor 10 revolutions (100000 counts) at 400 rpm.

- Enter parameter values as shown in the screen below.

- Enable the drive.
- Click the **Start** button to start the motor.
- Observe the movement of the inertia load disk.
- Select the **Alternating** option.

3. Press **Start** to execute the command. At the end of the movement, press **Start** again. Repeat several times, and observe the result.

   This option is useful for plug and reverse applications.

4. Clear the **Alternating** option.
   Reduce the **Cruise Velocity** value to **40** rpm, and press **Start**.

   Observe the movement of the inertia load disk and count the number of revolutions.

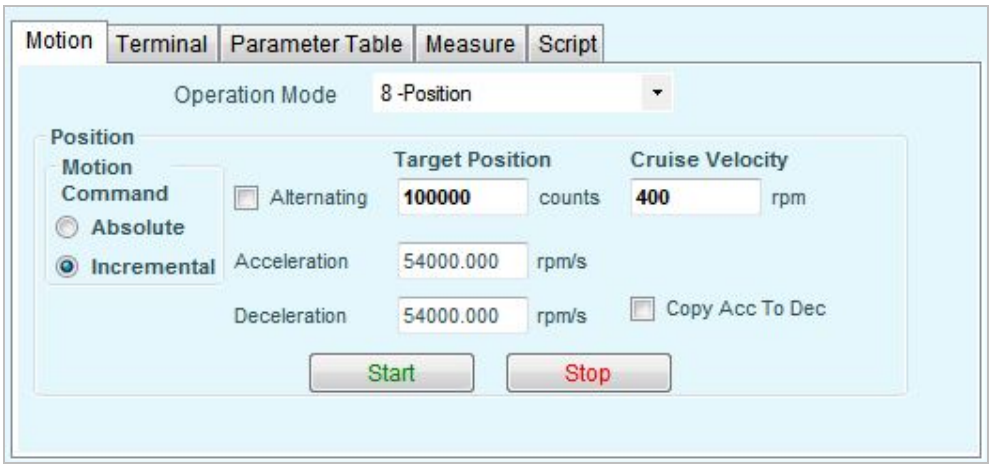
Absolute Position Command

> **Note:** An **incremental** command moves the motor the specified number of counts from its current location.
>
> An **absolute** command moves the motor the specified number of counts from the encoder 0 position.

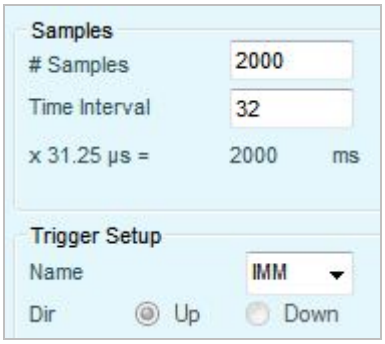
1. Define an absolute motion command that will move the motor 100000 counts, at 400 rpm.
   - Clear the **Alternating** option.
   - Select **Absolute**, and keep the same parameter values as shown in the screen above.
   - Click the **Start** button to start the motor.
   - Observe the movement of the inertia load disk, and the values displayed in the **Actual Values** section at the bottom of the screen.
2. Switch back to Incremental and execute a motion. Again note the Actual Values displayed on the screen.

Recording

1. Open the **Scope** screen.
2. In the **Motion** pane, enter values as shown in the screen below:



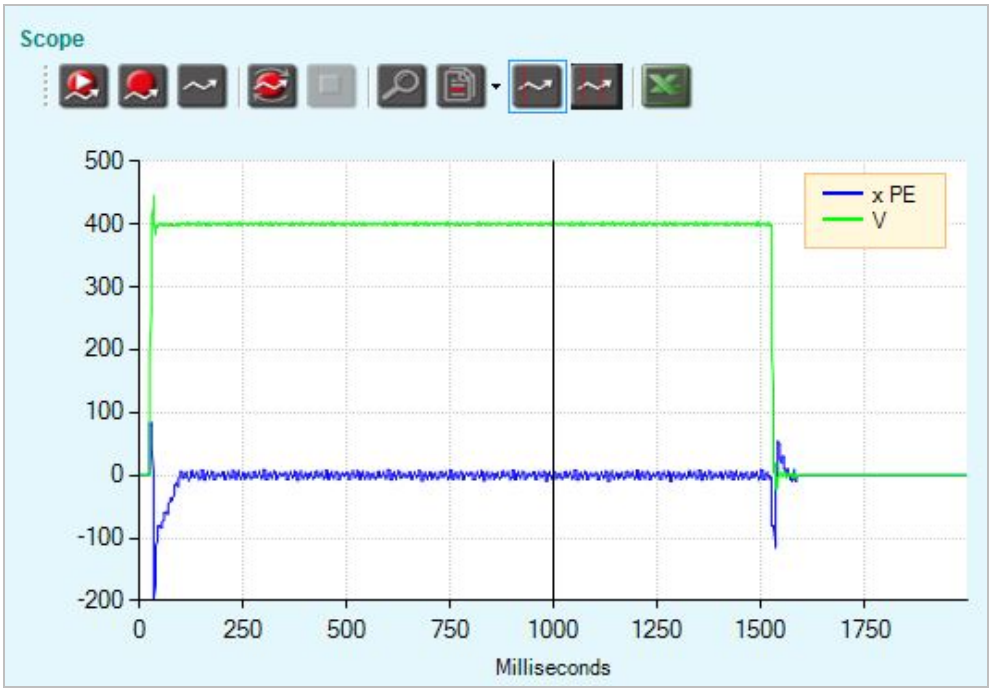
3. Click **Start** and verify the motion.
4. Set up the recording as you did previously for Velocity commands.



- Select two variables: **PE** (position error) and **V** (measured velocity).
- Scale the variable PE by a factor of 10.

5. Make sure drive is enabled, then click the **Move Record and Plot** button.

The plot soon appears:



6. In the **Motion** pane, change the options and values for the position commands, and record the movements. Observe the results.

Movement by Distance / Speed

In this task you will rotate the motor a specific distance (720 degrees) and speed (3 rps), and continuously record the motion.

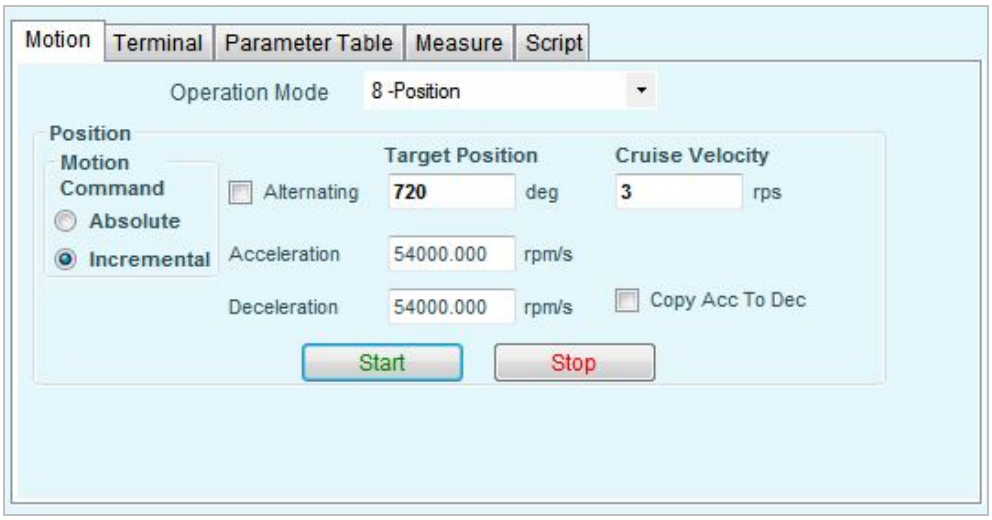
Since this task uses units of measurement that are different from the previous task, you need to change the defined CDHD motion units.

1. From the ServoStudio navigation sidebar, select **Motion Units**.

2. In the Motion Units screen, change the **Rotary** units as follows:

- Position: **2-deg**
- Velocity: **0-rps**
- Acc/Dec: 1-rpm/s (unchanged)

3. Click **Save** on the ServoStudio toolbar.
4. Now, go to **Scope** screen and open the **Motion** pane. Note the changes in the motion units.
5. Enter distance and speed values according to the new units:
   - Target Position (distance): **720 degrees**
   - Cruise Velocity (speed): **3 rps**
   - Click **Start**, and observe the movement.



6. Prepare to record the motion using the Recorder Setup pane:
   - Define the number of samples. Set to **2000**.
   - Define the time interval between the samples. Set to **32**.
   - Define the record trigger. Set to **IMM** for immediate activation
   - Select variables: **PE** (position error) and **V** (measured velocity).
7. Clear the chart.
8. Click the **Continuous Record and Plot** button. 
9. Click **Start**.
10. When motion stops, click **Start** again. Repeat once or twice.
11. Click the **Stop Recording** button. 
12. Restore the drive's default motion units. Go to the **Motion Units** screen, disable the drive, and change the **Rotary** units as follows:
    - Position: **1-count**
    - Velocity: **1-rpm**
    - Acc/Dec: 1-rpm/s (unchanged)

    Remember to click **Save**.

7 Fault Handling

7.1 Objective

In this session you will deliberately cause a drive fault, and practice various ways to recover from the fault.

7.2 Resources

Whenever a drive fault occurs, go to the **Enable & Faults** screen and check the list of faults and warnings.

You can also click the displayed hyperlink for more information and instructions for corrective actions.

After correcting the problem which caused the fault, the fault must be cleared. There are several ways to do this:

- In the **Enable & Faults** screen, click the **Faults|Clear Faults** button in the upper part of the screen. If the problem was indeed resolved, the fault will no longer be displayed.
- Note the **Faults/No Faults** segment of the status bar at the bottom of every ServoStudio screen. The segment is **green** as long as no faults exist; it is **red** whenever a fault exists. Right-click the segment to clear faults.
- Define a digital input as **2- Reset faults mode**. To clear faults, just switch on the digital input. (see chapter “Digital Inputs and Digital Outputs”)
- Disable the drive and immediately enable it again. In the Terminal screen or pane, enter the commands **K** and **EN**.

Refer to the following sections in the CDHD User Manual:

- Enable/Disable (Section 5.14)

7.3 Procedure

1. Locate the STO switches on the top of the Demo Kit.
2. Turn off one of the STO switches, and look at the 7-segment display on the drive.
3. You should see a flashing **n** (STO fault).
4. Open the **Enable and Faults** screen.

   Look the **Faults & Warning** pane.

- Click on the hyperlink **n**.

  The Help screen opens, showing a description of the fault.

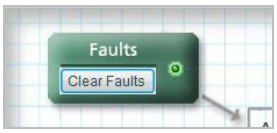
5. Turn the STO switch back on, and check the 7-segment display.

   The fault code **n** is still displayed.

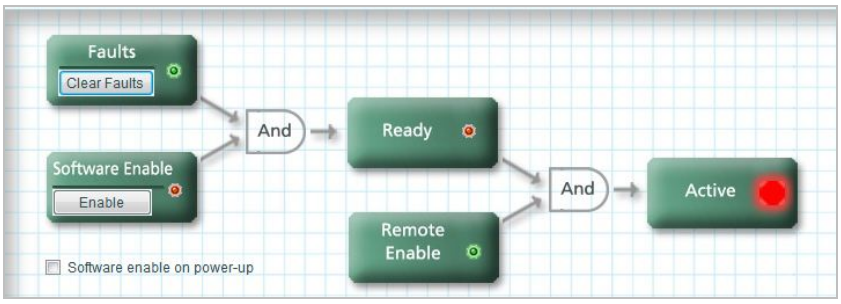
6. The fault is not cleared automatically.

   You need to clear the fault before you can resume working with the drive.

   - Click the **Faults - Clear Faults** button.

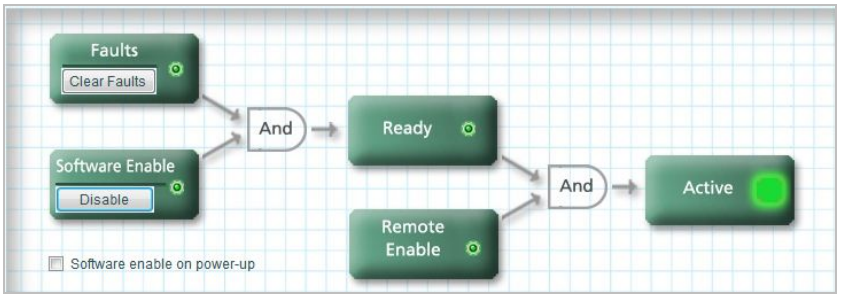


Now you see this:



- Click the **Software Enable - Enable** button.

Now you see this:



The drive is now enabled, as indicated by:

- The 7-segment display shows the OPMODE number and a dot, which indicates the drive is enabled (e.g., **8.**)
- The **Enabled** button is lit in the ServoStudio toolbar.

8 Digital Inputs and Digital Outputs

8.1 Objective

In this session you will:

- Set the functionality of digital inputs and outputs in the **Digital I/Os** screen.
- Perform operations using the digital I/Os.

8.2 Resources

The **Digital I/Os** screen enables you to configure functionality and polarity of the digital I/Os in your application, and to monitor the state of all digital I/Os.

- **Mode** defines the functionality of the digital input or output.
- **Inversion** inverts the polarity of a digital input or output; simply click the option to invert the polarity. As a result of inversion, I/O LED graphics in the software immediately change color, as do the output LEDs on the Demo Kit. The LEDs on the Demo Kit input switches do not change their state except when the switch is actually togged between on and off positions.
- **Connector** in the Digital I/Os screen indicates the pin number of the input on either the Controller (C) interface or the Machine (M) interface.
- **User Notes** allow you to add more specific definitions to the I/Os in your application. The **Save Notes** button saves a copy of any text you enter in the User Notes field.

Refer to the following sections in the CDHD User Manual:

- Digital I/Os (Section 5.12)

8.3 Procedure

Digital Inputs

Remote Enable Mode

By default, input 1 (IN 1) on the Demo Kit is defined as the Remote Enable switch. As long as the switch is on, the drive can be enabled.

1. Make sure the drive is enabled.
2. Open the **Digital I/Os** screen.

   You should see that Input 1 Mode is set to **1-Remote Enable**. You should also see the LED graphics for Input 1 and Fault Relay Mode are green, while all others are red.

3. On the Demo Kit, turn off switch **IN 1** and observe the effect:
   - The LED graphic on the screen turns red to indicate the switch is off.
   - The drive becomes disabled.
4. Turn the switch back on.
   - The LED graphic on the screen turns green.
   - The drive becomes enabled.
5. Leave the switch on, and select the **Inversion** option to invert the polarity of the input:
   - The LED graphic turns red.
   - The drive becomes disabled.
6. Turn the switch off, and observe the effect.
7. Clear the **Inversion** option.
8. Turn on switch **IN 1**.

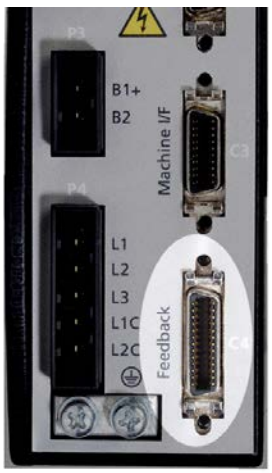
Reset Faults Mode

An input can be defined to clear faults.

In this task you will create a fault. For safety reasons, make sure the drive is disabled before you start this task.

1. On the Demo Kit, turn off switch **IN 1**.
2. In the Digital I/Os screen, set Input 2 Mode to **2-Reset Faults.**

3. Create a fault by unplugging the Feedback connector (C4).



4. You should see a flashing **r4** on the 7-segment display.
5. Reconnect the connector to remove the fault condition.
6. Clear the fault by turning on **IN 2** switch.
7. Immediately turn off the **IN 2** switch so that it will be ready for clearing a fault the next time one occurs.
8. Before you continue to the next task, do the following:
   - Set IN 2 Mode to **Idle**.
   - Turn on switch **IN 1**, and make sure drive is enabled.

Limit Switch Clockwise (CW) Mode

An input can be defined as a limit switch.

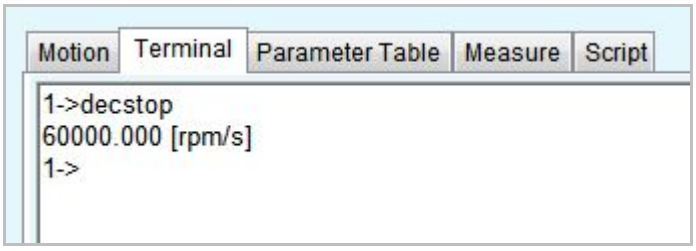
1. Make sure switch **IN 1** is **on**, and the drive is enabled.
2. In the Digital I/Os screen, set Input 3 Mode to **Limit Switch CW**.

You should now see a flashing **L1** on the 7-segment display.

L1 indicates that the motor has reached the limit switch in the clockwise direction. (L2 indicates counter-clockwise direction.) The motor cannot move in the clockwise direction, but it can be moved counter-clockwise.

3. On the Demo Kit, turn on switch **IN 3** (to simulate the motor reaching the switch).
4. Go to the **Scope** screen > **Terminal** pane.
   - Check the value of parameter **DECSTOP**:

     `DECSTOP <Enter>`

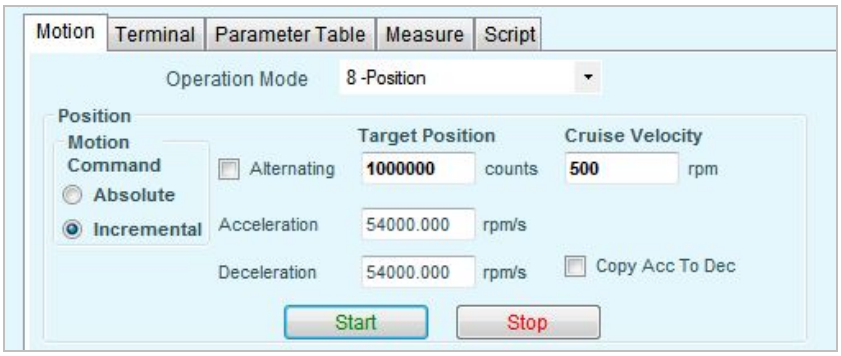


     DECSTOP is the deceleration value used for emergency stops and for stopping upon reaching a limit switch. The default value is 60,000 rpm/s.

   - If 60,000 is not displayed, enter the instruction:

     `DECSTOP 60000 <Enter>`

5. Go to the **Scope** screen> **Motion** pane, and define a movement using the settings shown in the screen below.



- Start the movement.
- While the motor is in motion, turn off switch **IN 3**.
- Observe the stopping of the motor. (It stops immediately.)
- Turn on switch IN 3.

6. In the Terminal pane, change the value of DECSTOP to **6000**.
DECSTOP 6000 <Enter>

7. Go to the Motion pane, and start the movement.
- While the motor is in motion, turn off switch **IN 3**.
- Observe the stopping of the motor. (Probably no discernible difference.)
- Turn on switch IN 3.

8. In the Terminal pane, change the value of DECSTOP to **600**.

9. Go to the Motion pane, and start the movement.
- While the motor is in motion, turn off switch **IN 3**.
- Observe the stopping of the motor. (It slows before stopping.)
- Turn on switch IN 3.

10. In the Terminal pane, change the value of DECSTOP to **60**.

11. Go to the Motion pane, and start the movement.
- While the motor is in motion, turn off switch **IN 3**.
- Observe the stopping of the motor. (Takes a long time to stop.)

12. Before you continue to the next task, do the following:
- In the Terminal pane, change the value of DECSTOP to **60000**.
- In the Digital I/Os screen:
  - Makes sure switch IN 1 is on and switch IN 3 is off.
  - Set Input 3 Mode to **0-Idle**.

Digital Outputs

In the next tasks you will define digital output functions and perform operations that affect the outputs.

Active Mode

In the Digital I/Os screen, set Output 1 Mode to **Active.**

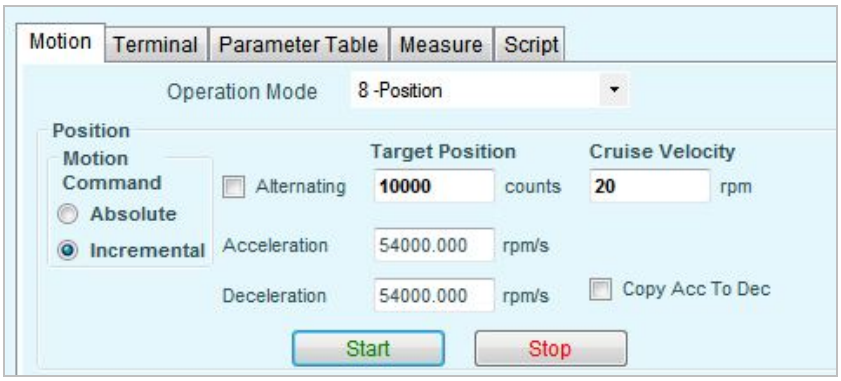
1. Watch the LED for output 1 on the Demo Kit and in the Digital I/Os screen, and turn switch **IN 1** off and on.
2. Click the **Enable|Disable** button in the ServoStudio toolbar, and observe the effect.
3. Before you continue to the next task, do the following:
   - Make sure switch IN 1 is off.
   - Set Output 1 Mode to **0-Idle**.
   - Turn on switch IN 1.

Note: If Digital Input 1 Mode is set to **1-Remote Enable**, switch IN 1 must be off when the Output 1 Mode is reset to 0-Idle. Otherwise the LED will remain lit.

Stopped Mode

1. In the Digital I/Os screen, set Output 3 Mode to **Stopped**.

2. Go to the **Scope** screen> **Motion** pane, and define a movement using the settings shown in the screen below.



   - Start the movement.
   - Observe what happens when the motor stops.

     (May be flickering of the LED, during the motor settling time.)
3. Before you continue to the next task, do the following:
   - Set Output 3 Mode to **0-Idle**.

9 More Recording Tools

9.1 Objective

In this session you will run a script and record the motion, and then practice using some of the tools in the Scope screen.

9.2 Resources

Refer to the following sections in the CDHD User Manual:

- Data Recording, Scope Screen (Section 6.14)

9.3 Procedure

1. Go to the **Scope** screen.
2. In the Record Variables table, make sure all variables are scaled to 1.

   You can adjust scaling factors at any time to help you view results.
3. Open the **Script** pane.
4. Enter the following script. (You can simply copy-paste the text.)

   The comments are included to help you understand each line.

```
k                       ; Disable the drive
opmode 8                ; Position mode
acc 1000                ; Motion acceleration
dec 1000                ; Motion deceleration
recoff                  ; Cancel any active recording.
record 64 2000 "v "pe   ; Record initialization. Record time 4 seconds
rectrig "imm            ; Record trigger. Start recording immediately
en                      ; Enable the drive
moveinc 100000 500      ; Positive position command of 10 rev in 500 rpm
#Plot                   ; Plot
k                       ; Disable the drive
```

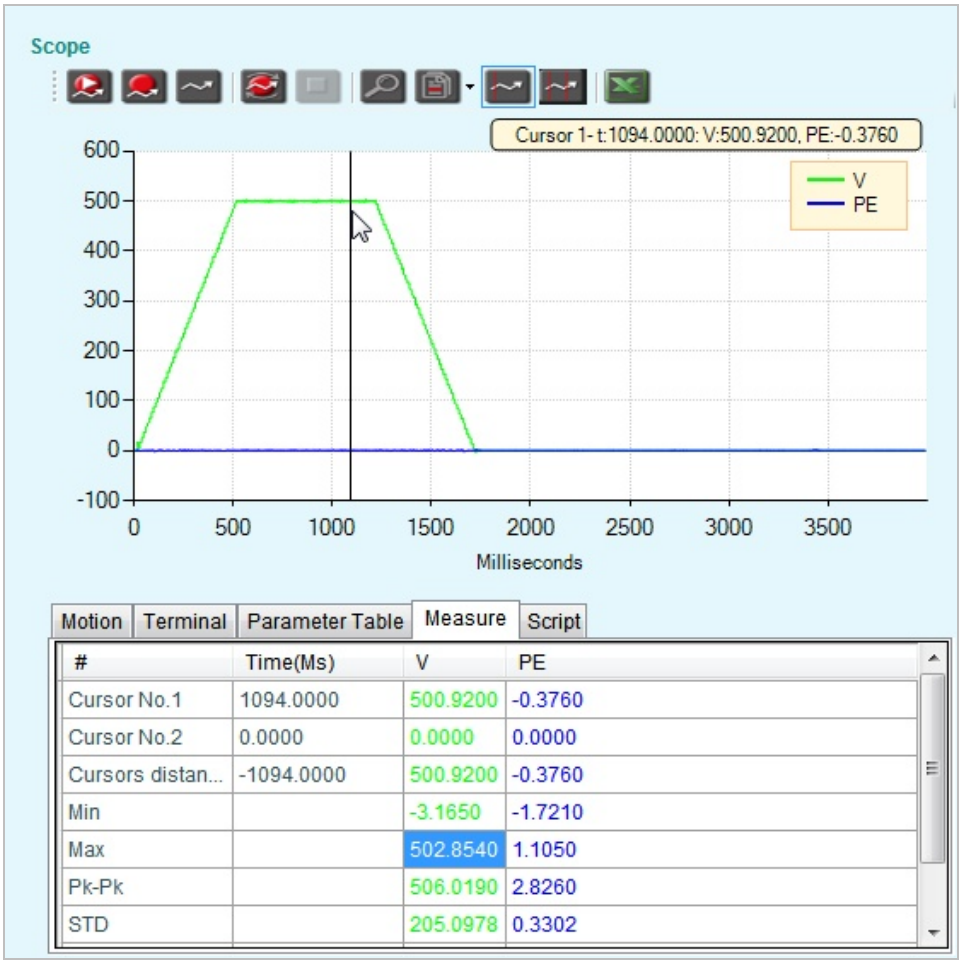
5. Run the script by clicking the Script Start button:

6. Wait for the motion plot to appear in the **Scope** pane.

7. Measure the maximum velocity of the movement:

- Open the **Measure** tab. You will see values for the maximum, minimum, peak to peak, and mean velocity, and the standard deviation (STD) of the velocity value.
- Using the mouse, slide the line cursor across the plot, and see the values at precise points.



8. Hide a trace; for example, the measured velocity signal (V):

- Place the mouse on the V trace, and right-click.
- Select **Hide Trace**.

9. Restore the original plot without running the script again:

- On the Scope toolbar, click the **Plot** (Get current data from drive) button:

10. Zoom in to the graph:

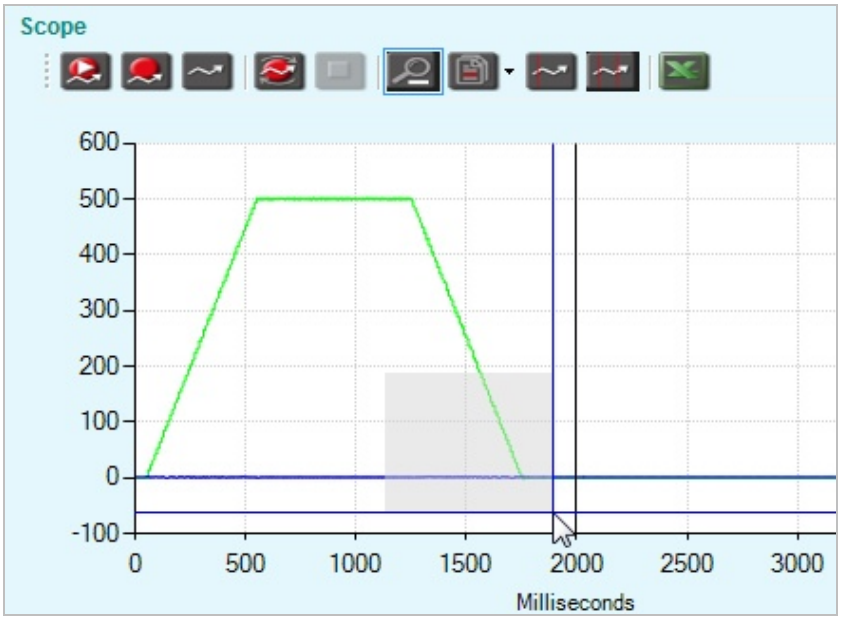
- On the Scope toolbar, click the **Zoom** button.

This button toggles the function of the cursor, so that it can be used for zooming into a graph.

When **Zoom** is selected, a bar appears on the button.

When the bar is displayed on the button, click the button to zoom out.

- Click the **Zoom** button to restore the graph to the original view.
- Using the left mouse button, click-and-drag to select an area on the graph for magnification.



11. View the FFT of the measured velocity signal (V).

- Place the mouse on the V trace, and right-click.
- Select **FFT Trace**.
- Click **Refresh**.

12. Save the recording.

- Place the mouse anywhere in the graph area, and right-click.
- Select **Save As…**
- Save the file as a .CSV file.

You can also save files using the **File** option in the **Scope screen**; use **Chart Options** or right-click anywhere on graph.

10 Introduction to Scripts

10.1 Objective

In this session you will use a script to perform the following tasks:

- Rotate the motor in Position mode (OPMODE 8); it will move 10 revolutions in the positive direction, and then 10 revolutions in the negative direction.
- Record the motor velocity (V) and position error (PE) during the movement.

10.2 Resources

In this session you will you use the **Expert** screen > **Script** pane.

Refer to the following sections in the CDHD User Manual:

- Dashboards, Expert Screen (Section 4.2.3)
- Appendix: Scripting (Chapter 9)

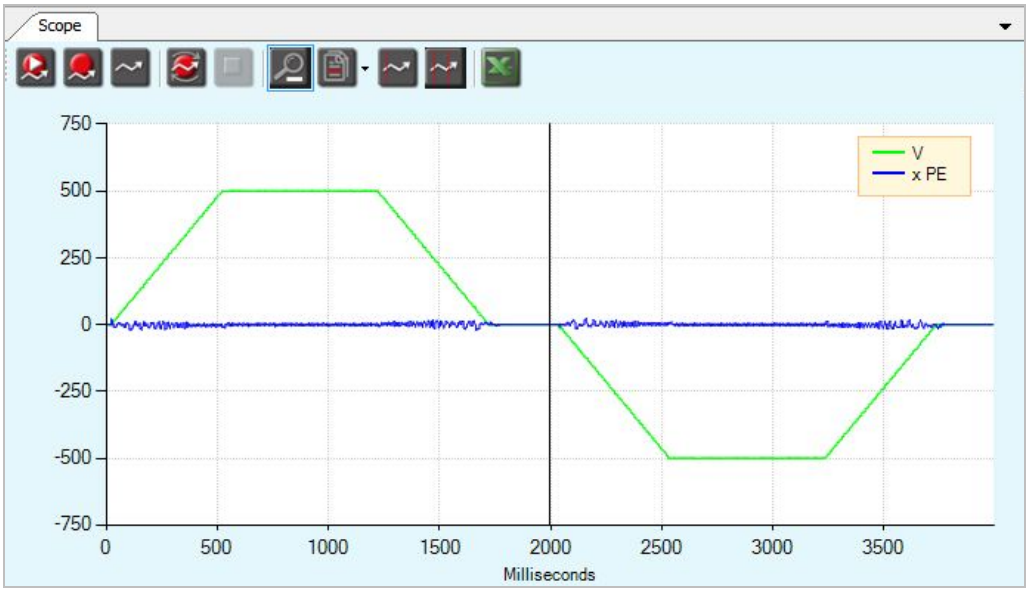
10.3 Procedure

1. Open the **Expert** screen, and select the **Script1** tab.
2. In the script pane, enter the following script. (You can simply copy-paste the text.)

   The comments are included to help you understand each line.

```
k                       ; Disable the drive
opmode 8                ; Position mode
acc 1000                ;Motion acceleration
dec 1000                ;Motion deceleration
recoff                  ; Cancel any active recording.
record 64 2000 "v "pe   ; Record initialization. Record time 4 seconds
rectrig "imm            ; Record trigger. Start recording immediately
en                      ; Enable the drive
moveinc 100000 500      ; Positive position command of 10 rev in 500 rpm
#Delay 2000             ; Delay of 2 seconds
moveinc -100000 500     ; Negative position command of 10 rev in 500 rpm
#Delay 2000             ; Delay of 2 seconds
#Plot                   ; Plot
K                       ; Disable the drive
```

3. Run the script. (Click the **Start** button on the Script pane toolbar. 
   - Observe the movement of the motor shaft disk.
   - Look at the motion plot in the **Scope** pane.



The first movement must be completed before the second movement command can be issued. This script uses a time delay of 2 seconds between the motions, which is sufficient for this particular task.

- Right-click anywhere in the graph area, and select **Clear Chart.**

4. For better precision, and to ensure the first movement has ended before the second one starts, modify the script as shown here.

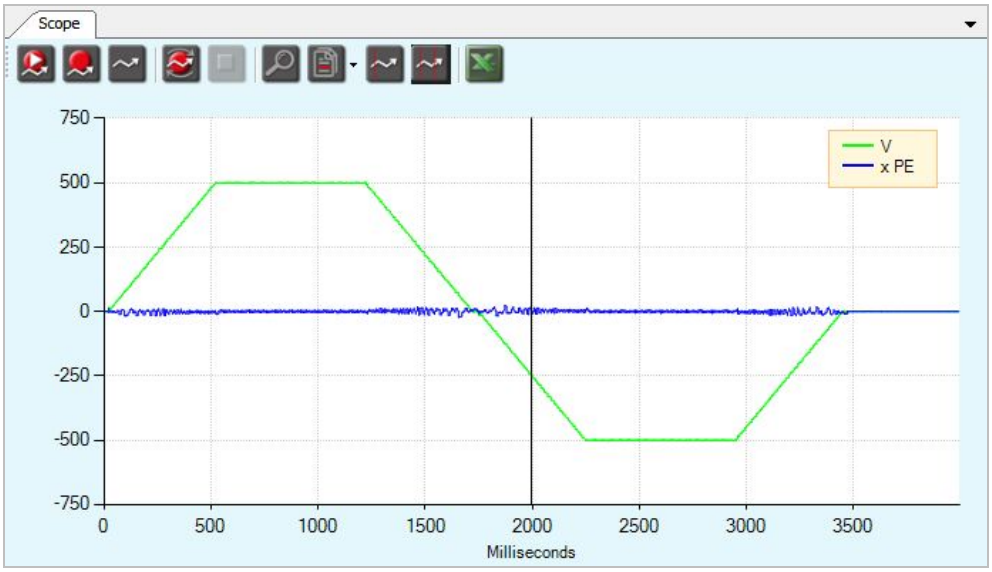
- Select the **Script2** tab, and enter the following script.

```
k                       ; Disable the drive
opmode 8                ; Position mode
acc 1000                ;Motion acceleration
dec 1000                ;Motion deceleration
recoff                  ; Cancel an active records
record 64 2000 "v "pe   ; Record initialization. Record time  4 seconds
rectrig "imm            ; Record trigger. Start recording immediately
en                      ; Enable the drive
moveinc 100000 500      ; Positive position command of 10 rev in 500 rpm
#while v>10             ; While loop
#Delay 10
#End_While              ; End of the while loop
moveinc -100000 500     ; Negative position command of 10 rev in 500 rpm
#Plot                   ; Plot
k                       ; Disable the drive
```

- Run the script. Observe the movement of the motor, and look at the motion plot in the **Scope** pane.
- Note the differences between the first and second recordings.

Note:	To easily compare two plots, right click in the plot area, and select **Reference / Previous Set** > **Show Previous Set**.

The second script uses a **While** loop, which runs repeatedly until the motor completes the first command (moveinc 100000 500). Only then is the second motion command (moveinc -100000 500) executed.



- Right-click anywhere on the plot area, and select **Clear Chart.**

5. Modify the script by defining a variable that contains the distance of the position command.

Note: Variable names must begin with the character **$**.

- Select the **Script3** tab, and enter the following script.

```
#Var $distance              ; Variable definition
$distance=100000
k                           ; Disable the drive
opmode 8                    ; Position mode
acc 1000                    ;Motion acceleration
dec 1000                    ;Motion deceleration
recoff                      ; Cancel an active records
record 64 2000 "v "pe       ; Record initialization. Record time - 4 seconds
rectrig "imm                ; Record trigger. Here set to immediately start
                              recording
en                          ; Enable the drive
moveinc $distance 500       ; Positive position command of 10 rev in 500 rpm
#while v>10                 ; While loop
#Delay 10
#End_While                  ; End of the while loop
$distance=-$distance
moveinc $distance 500       ; Negative position command of 10 rev in 500 rpm
#Plot                       ; Plot
k                           ; Disable the drive
```

- Run the script and record the motion.

The result is similar to the previous script. The difference is in the use of a variable.

11 Analog Input

11.1 Objective

In this session you will:

- Configure analog input variables.
- Rotate the motor using an analog current command.
- Rotate the motor using an analog velocity command
- Record the input analog voltage.

11.2 Resources

Refer to the following section in the CDHD User Manual:

- Analog I/Os (Section 5.13)
- Analog Current Mode (Section 6.2)
- Analog Velocity Mode (Section 6.3)
- Data Recording (Section 6.14)

11.3 Procedure

Analog Input Configuration

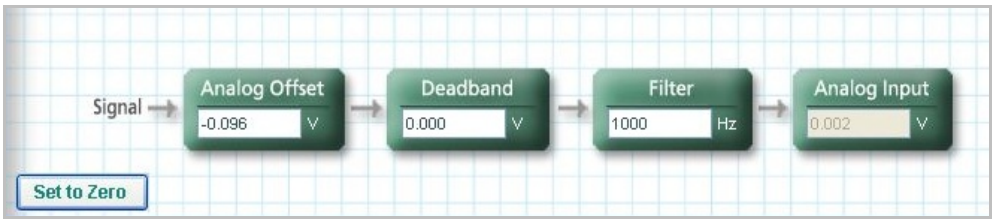
Open the **Analog I/Os** screen, and do the following:

- Make sure the drive is online and disabled.
- Rotate the analog input dial (ANIN 1) until the LCD display reaches 0.

  It does not have to be exactly zero. ±0.5 is close enough.
- Press the **Set to Zero** button.

  This modifies the **analog offset** value, causing the value of the analog input 1 signal to become 0.

  Make sure the **Analog Input** box in ServoStudio displays **0**.
- Set the **Deadband** to **0**.
- Set the **Filter** to **1000** Hz.



Analog Current Command

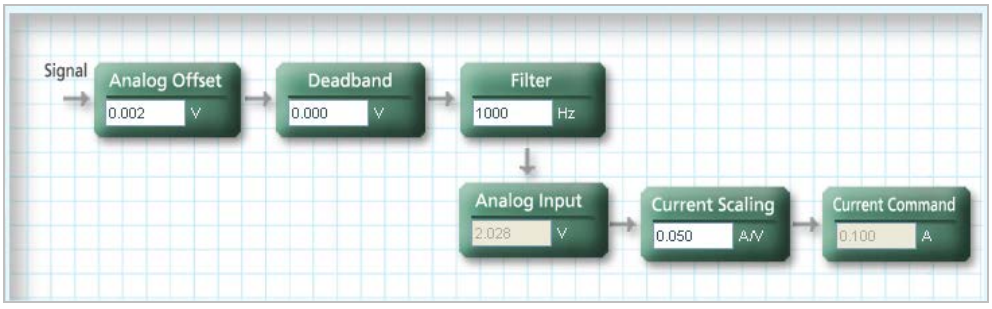
In Analog Current operation mode (OPMODE 3), only the CDHD's current loop is active, and the drive responds to a command from the primary analog input.

In this task you will produce an analog signal that applies a current command of 0.1 ampere.

1. Open the **Motion** screen.
   - Make sure the drive is online and disabled.
   - Set the Operation mode to **3-Analog Current.**
2. Set the **Current Scaling** to **0.05 A/V**.

   With such a setting, every 1V in the analog input will produce a current command of 0.05A.

   For example, an analog input of 10 V will produce a current command of 0.5A.



3. Enable the drive.
4. Watch the motor and the following boxes in the schematic diagram:
   - **Analog Input**: shows the voltage applied to the analog input.
   - **Current Command**: shows the current command to the drive (varies according to the analog input voltage and the current scaling).
5. Now, SLOWLY rotate the **ANIN 1** dial in the clockwise direction until the **Current Command** reaches 0.1 A.

Notes: Current is proportional to the acceleration of the motor. When injecting a constant current to the motor, it will begin to accelerate (the speed will increase).

If the motor stops, check if the drive has disabled and **J** is flashing on the drive's LED display; this indicates a velocity error. Clear the fault and repeat the task.

6. To stop the spinning motor, slowly rotate the **ANIN 1** dial in the counter-clockwise direction until the motor stops.
7. Disable the drive.

Analog Velocity Command

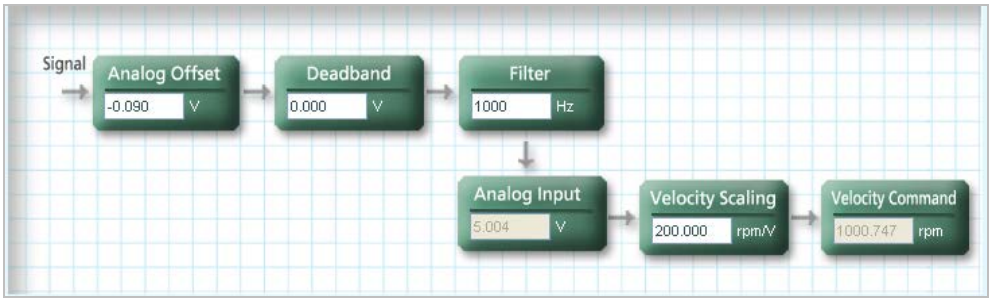
In Analog Velocity operation mode (OPMODE 1), the CDHD's current **and** velocity loops are active, and the drive responds to a command from the primary analog input.

In this task you will produce an analog signal that applies a velocity command of 1000 rpm.

1. Open the **Analog I/Os** screen, and do the following:
   - Make sure the drive is online and disabled.
   - Rotate the **ANIN 1** dial until the LCD display is within ±0.5.
   - Press the **Set to Zero** button.
2. Open the **Motion** screen.
   - Make sure the drive is online and disabled.
   - Set the Operation mode to **1-Analog Velocity.**
3. Set the **Velocity Scaling** to **200 rpm/V**.

   With such a setting, every 1V in the analog input will produce a command of 200 rpm.

   For example, an analog input of 10V will produce a velocity command of 2000 rpm.



4. Enable the drive.
5. Watch the motor and the following boxes in the schematic diagram:
   - **Analog Input**: shows the voltage applied to the analog input.
   - **Velocity Scaling**: shows the velocity command to the drive (varies according to the analog input voltage and the velocity scaling).
6. Now, SLOWLY rotate the **ANIN 1** dial in the clockwise direction until the **Velocity Command** reaches 1000 rpm.
7. To stop the spinning motor, slowly rotate the **ANIN 1** dial in the counter-clockwise direction until the motor stops.
8. Disable the drive.

Record

In this task you will record the analog input voltage (**ANIN1**) and the motor speed command (**VCMD**). During the record time, you will change the analog input voltage and see how it influences the motor speed.

1. Open the **Analog I/Os** screen, and do the following:
   - Make sure the drive is online and disabled.
   - Rotate the **ANIN 1** dial until the LCD display is within ±0.5.
   - Press the **Set to Zero** button.
2. Open the **Scope** screen, and select the **Motion** tab.

   The values from the previous task are still displayed.

3. Using the **Recorder Setup** pane, prepare to record for 8 seconds.
   - Define the number of samples. Set to 2000.
   - Define the time interval between the samples. Set to 128.
   - Define the record trigger. Set to **IMM** for immediate activation.
   - Select variables: **VCMD** (velocity command) and **ANIN1** (Analog input voltage.

Note: By default, the **ANIN1** variable is not displayed in the **Record Variable** table.

To add the variable ANIN1, click in the blank Name cell at the top, type **ANIN1**, and press **Enter**. Then, select the variable by clicking the **Select** box.

4. Enable the drive.
5. Begin the recording and then generate the movement:
   - Click the **Record and Plot** button in the **Scope** toolbar. 
   - Gently rotate the **ANIN 1** dial in the clockwise until motion begins, and counterclockwise until motion stops.

   Repeat this step several times to see how the plot changes according to how you controlled the ANIN 1 dial during the recording.
6. Change the scaling of the **ANIN1** variable:
   - Multiple ANIN 1 by 50; the two traces show a similar form.
   - Multiply ANIN 1 by 200, and the two traces will exactly overlap.

Deadband

Deadband is a range of voltages which are interpreted as 0. Deadband is used to prevent the drive from responding to voltage noise near the zero point of the analog input.

1. Open the **Analog I/Os** screen, and do the following:
   - Make sure the drive is online and disabled.
   - Rotate the **ANIN 1** dial until the LCD display is within ±0.5.
   - Press the **Set to Zero** button.
2. Open the **Scope** screen, and select the **Motion** tab.
   - Set the Operation mode to **1-Analog Velocity.**
3. In Scope screen, open the **Script** tab.

   Copy the following script:

```
#Var $offset              ; Variable representing the analog input offset value
$offset=-4.5              ; Initial analog input offset value
k                         ; Disables the drive
anin1db 2                 ; Deadband value of 2 V
anin1vscale 100           ; Velocity scaling factor definition
anin1offset $offset       ; Changes the analog input command by adding an
                            offset
recoff                    ; Cancels any active recording
record 128 1500 "anin1 "v ; Records configuration
en                        ; Enables the drive
```

```
rectrig "imm                ; Recording trigger set to immediate
#while $offset<5            ; Starts While loop
#Delay 500                  ; Half a second delay
$offset=$offset+1           ; Changes the offset variable value
anin1offset $offset         ; Changes the analog input command by adding an
                              offset
#end_while                  ; Ends While loop
#plot                       ; Plots the recorded variables
k                           ; Disables the drive
```

4. Run the script.

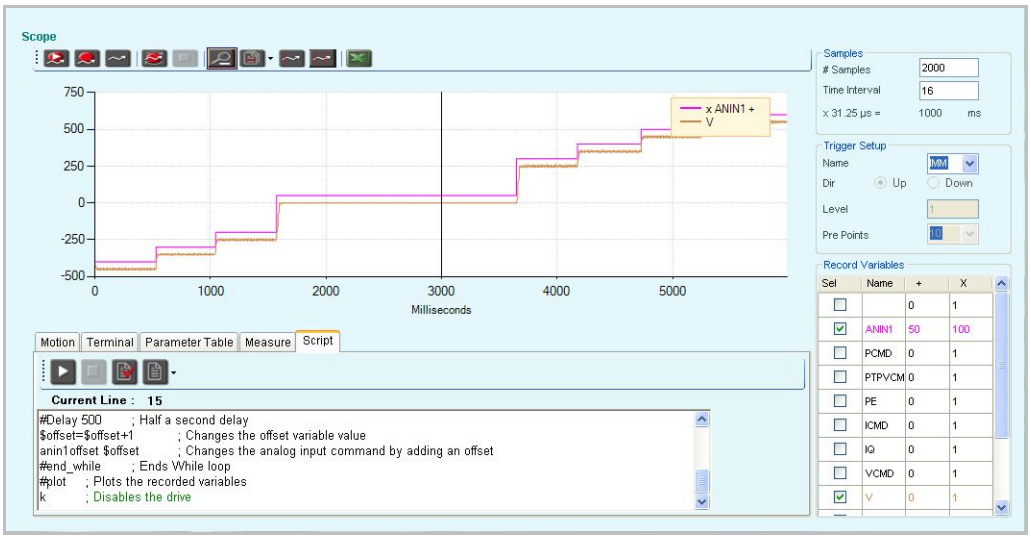
Watch the motor and the Scope screen.

5. The plot appears.

The traces of the two recorded variables may overlap. If so, adjust the offset of ANIN1 by 50, as shown below, for better viewing.

The script causes the analog input to change by keeping the analog input voltage at a fixed value, and changing only the offset.

When the analog input value is in the range -2< V <2 (ANIN1 is multiplied by 100), no motion occurs.



12 Analog Output

12.1 Objective

In this session you will learn how the analog output voltage can represent the value of certain parameters. You will use the analog output to:

- Monitor the speed of the motor.
- Monitor the current command.

12.2 Resources

Refer to the following section in the CDHD User Manual:

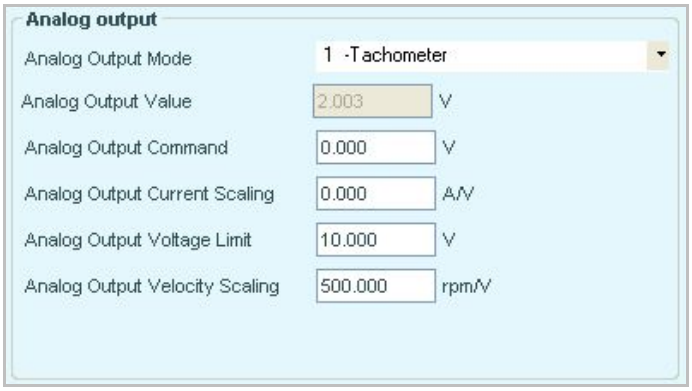
- Analog Output (Section 5.13.3)

12.3 Procedure

Analog Output as Speed Monitor

In this task you will use the analog output to monitor the motor speed.

1. Make sure the drive is online and disabled.
2. Open the **Analog I/Os** screen. In the **Analog Output** pane do the following:
   - Set **Analog Output Mode** to **1 –Tachometer**.
   - Set **Analog Output Voltage Limit** to **10** V.
   - Set **Analog Output Velocity Scaling** to **500** rpm.



3. Open the **Motion** screen.
   - Make sure the drive is online and disabled.
   - Set the Operation mode to **3-Serial Velocity.**
   - Rotate the motor at 1000 rpm.

   For help, refer to Chapter 5: Basic Operation – Velocity Control Loop.

4. While the motor is still turning, open the **Analog I/Os** screen.

   Look at the **Analog Output Value** field. The value indicates the motor speed:

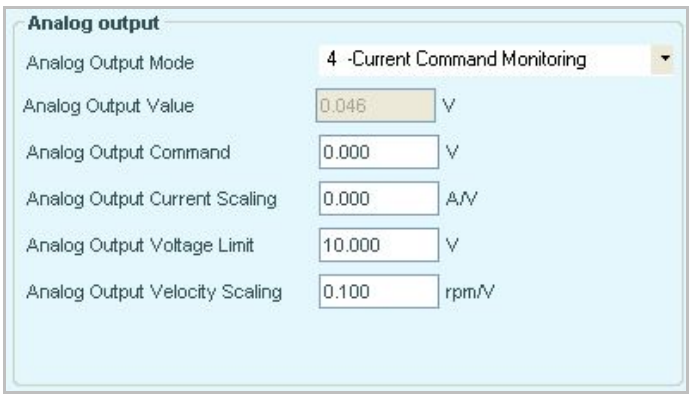
   Velocity =Analog Output Voltage × Velocity Scaling.

Note:	You can also connect a BNC cable to the **Analog Output** connector on the Demo Kit, and read the output voltage using a device such as a scope or a voltmeter.

Analog Output as Current Monitor

In this task you will use the analog output to monitor the current that is injected to the motor.

1. Make sure the drive is online and disabled.
2. Open the **Analog I/Os** screen, and do the following:
   - Set **Analog Output Mode** to **4 –Current Command Monitoring**.
   - Set **Analog Output Voltage Limit** to **10** V.
   - Set **Analog Output Velocity Scaling** to **0.1** rpm/V



3. Open the **Motion** screen.
   - Make sure the drive is online and disabled.
   - Set the Operation mode to **3-Serial Velocity.**
   - Rotate the motor at 1000 rpm.

   For help, refer to Chapter 5: Basic Operation – Velocity Control Loop.
4. While the motor is still turning, open the **Analog I/Os** screen.

   Look at the **Analog Output Value** field. The value indicates the motor speed:

   Current =Analog Output Voltage × Current Scaling.

Note:	You can also connect a BNC cable to the **Analog Output** connector on the Demo Kit, and read the output voltage using a device such as a scope or a voltmeter.

13 Gear Mode

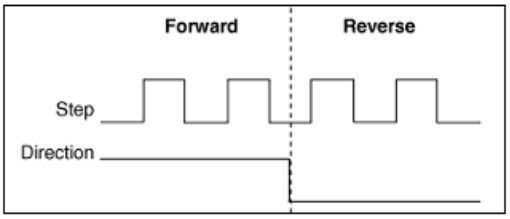
13.1 Objective

In this session you will issue a **Pulse and Direction** command to the drive.

13.2 Resources

Pulse and Direction is a simple method for controlling the motor motion. You can issue commands to the motor using two differential signals:

- **Pulse** – A signal that controls motion distance and speed. The pulse frequency is proportional to the motor speed.
- **Direction** – A signal that controls the direction of motion



Refer to the following section in the CDHD User Manual:

- Gear Mode (Section 6.6)

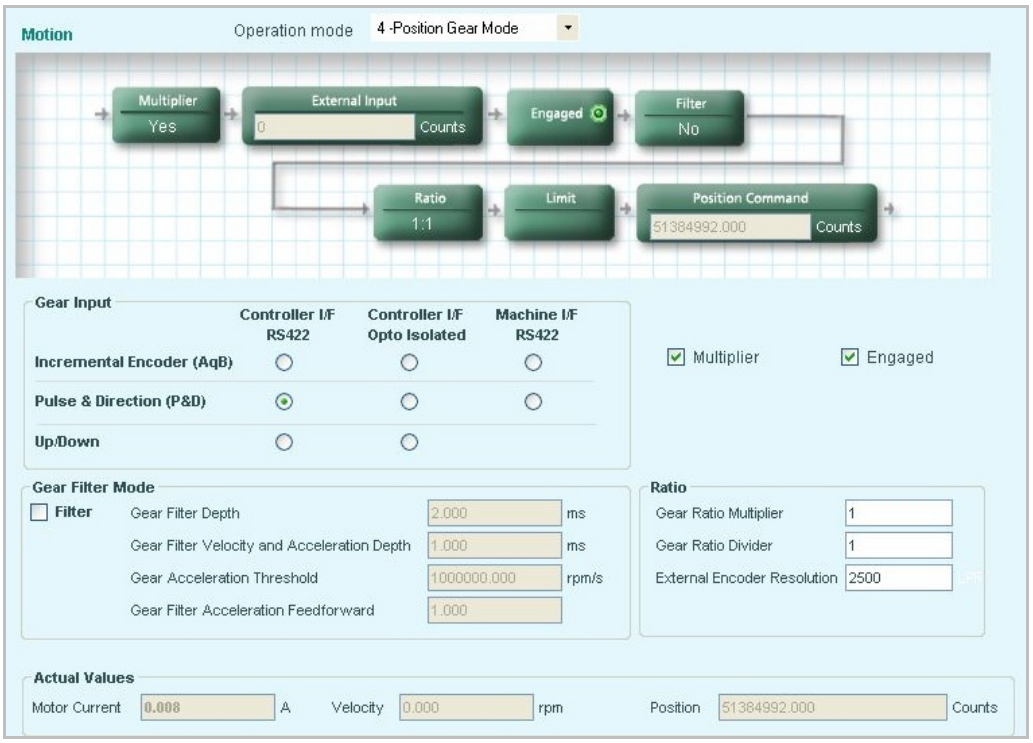
13.3 Procedure

Pulse and Direction Configuration

1. Open the **Motion** screen
   - Make sure the drive is online and disabled.
   - Set the Operation mode to **4- Position Gear Mode.**
2. Define the Gear variables as follow:
   - **Gear Input:**

     Select the option Controller/IF RS422 and Pulse & Direction.
   - **Gear Filter Mode:**

     Make sure filter is not selected.
   - **Ratio:**
     - Gear Ratio Multiplier: **1**
     - Gear Ratio Divider: **1**
     - External Encoder Resolution: **2500**
   - Multiplier: **Yes**
   - Engaged: **Yes**



Command

1. On the Demo Kit, set the **P&D Direction** switch to the center position, which is the P&D state.
2. On the Demo Kit, set the **Pulse Generator** selector switch to the Controller I/F state.
3. Enable the drive.
4. Rotate the **External Pulse Generator** dial.

   The **External Pulse Generator** dial generates 120 pulses per revolution.

The input signal is subject to gearing calculations that allow you to set the ratio of input pulses to encoder counts. Gearing sets up a relationship between the number of input pulses and the position increments of the motor shaft. The rate at which position increments of the motor shaft (motor speed) occur is determined by the gearing relationship and the line frequency of the pulse train. The gearing relationship is as follows:

$$\frac{GEARIN}{GEAROUT} \times \frac{1}{XENCRES}$$

If the absolute value of **GEARIN** is equal to **GEAROUT**, and if **XENCRES** is equal to encoder resolution (after quadrature), then one pulse on the input is equivalent to one count of the motor feedback.

The Demo Kit has an encoder resolution of 2500 lines/revolution; therefore, the settings used in this task result in one motor revolution for every 2500 pulses.

CDHD Servo Drive

Technical Training Manual

Revision 2.0

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